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Study on of frame section structure of crystalline silicon solar modules

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Abstract

The article studied under different frame section of the structure of the mechanical load performance of solar module, through the software simulation of two different structure stress analysis, and the different cross section aluminum frame structure of a variety of mechanical load testing, compare the different cross section of the structure of the aluminum frame of bearing capacity and deformation degree, and under different deformation degree in the corresponding micro-crack degree and the output power attenuation ratio. The results show that: 1. The mechanical loads of different sections have micro-crack and power attenuation; 2.The degree of deformation on the aluminum frame used for solar modules is not completely positively correlated with the degree of micro-crack and output power; 3. Through the analysis of the micro-crack location of solar modules, the stress point is the main reason for the micro-crack.

Keywords

Solar module; Cross section structure; Output power; Mechanical load; Degree of micro-crack.

1. Introduction

Since the 20th century, in the context of global energy crisis and environmental pollution, the development and utilization of renewable energy has increasingly become the first choice of the international community, and is also a key issue of China's future energy development strategy [1-3].As one of the renewable energy sources, solar energy is completely clean, pollution-free, and inexhaustible. It has become the most potential energy in the 21st century.

On December 12, 2020, President Xi Jinping proposed "Building on Past Achievements and Launching a New Journey for Global Climate Actions" at the Climate Ambition Summit. In it, he mentioned that peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060. and bring its total installed capacity of wind and solar power to over 1.2 billion kilowatts.

Human's use of solar energy has made rapid progress from heating and fire to photovoltaic (solar module). Nowadays, solar module has gradually replaced petrochemical energy and occupied an important position in the field of new energy [4].However, it has inevitably encountered a variety of difficulties in the development process of photovoltaic products， In the process of using, the solar module is micro-cracked under the action of external force, which reduces the reliability. In order to ensure that the production, transportation, installation, use, weather resistance and other reliability problems can meet the power generation requirements of the product, the aluminum alloy frame of solar modules plays a great role. In addition to protecting the solar modules, it also plays a role of fixing with the photovoltaic bracket [5-7], which is generally summarized as follows:

1. As the main frame of solar modules, it plays the main roles of support, compression resistance and collision avoidance, reducing internal micro-crack of products, improving mechanical strength of products and avoiding output power decline [8].；

2. Protect the glass on the four sides of photovoltaic module products, and combine with silica gel to realize the complete sealing of photovoltaic module products, avoid water seepage inside the product and prevent hydrolysis [9-10]；

3.In the process of transportation, handling, installation and fixing of solar modules, ergonomics is satisfied, which is convenient for the installation and use of the products；

According to the above effects, from the point of reducing the output power attenuation, this paper verifies the influence of different aluminum alloy frame cross section structure on the output power of solar modules through mechanical load experiments in the environment of simulated weather resistance , so as to obtain a frame cross section structure that is beneficial to the output power of solar modules.

2. Experimental

2.1. Theoretical Model

The SolidWorks mechanical design and analysis software is used to conduct simulation test analysis on the two aluminum frames ,which the respective cross-sections are shown in Figure 1. In the same simulation test environment, the characteristics of aluminum frames of different cross-sections are compared, and the theoretical simulation scheme is shown in Figure 2.

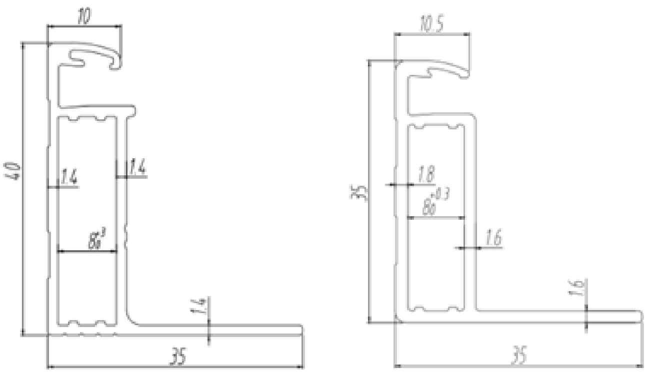

Figure 1： Different cross sections

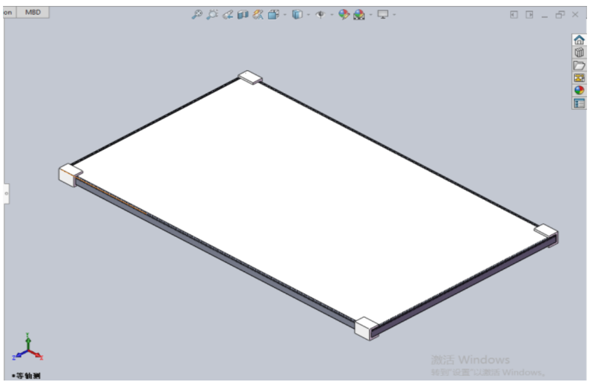

Figure2 : Isoaxonometric simulation 3D view

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2.2. Experimental Samples

The main process of photovoltaic modules is as follows: laser scribing, stringing,layout,1st EL test, lamination, framing , junction box installation , solidification, the output power testing, 2nd EL test, high voltage testing, packaging .

Materials:1755mm*1038mm*40mm and 1755mm*1038mm* 35mm aluminum alloy frame produced by Shandong WeiShi New Energy Co., Ltd， . The rest of the experimental materials were consistent in order to ensure the uniformity of experimental variables.

Test instrument: EL test machine(EL-Z4 Plus) is from PeiDe Optoelectronics Technology (Shanghai) Co., Ltd； PASAN transient model simulation instrument was used for power test. The instrument size was SUNSIM3C.Mechanical load test was conducted by Shanghai Hance Experimental Equipment Co.,Ltd. The instrument model was HCPV-07A.

2.3. Experimental Scheme

There are two ways to install photovoltaic modules: tilt and tile.Mechanical load experiments with different intensities were carried out for the two installation modes respectively. The experimental conditions are shown in Table 1, and the mechanical loads pressure curve within the test time is shown in Figure 4.After the mechanical load experiment, the module power and EL images were tested respectively.

Table 1 experiment condition

Item	Test 1	Test 2	Test 3	Test 4
Frame	35mm	40mm	35mm	40mm
Angle	10°	10°	0°	0°
Pressure	2400pa	2400pa	5400pa	5400pa
Time	6h	6h	6h	6h

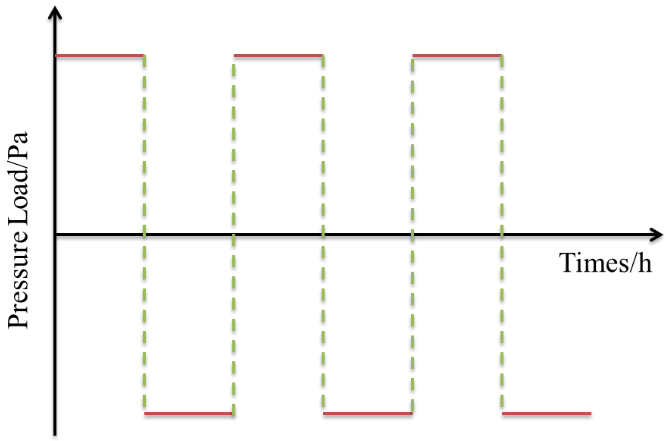
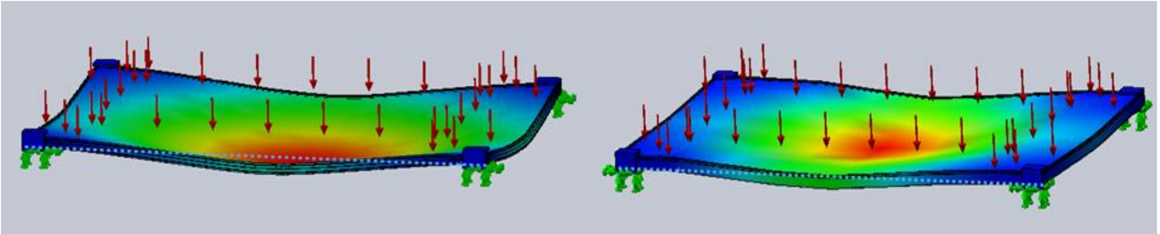


Figure. 3： mechanical loads pressure curve

3. Results And Discussion

3.1. Solidworks analysis

The pressure analysis of aluminum alloy with different sections was carried out by SolidWorks simulation software, as shown in Fig. 5.As the Figure.5 showers, the shape variable of 40-frame aluminum alloy is smaller than that of 35-frame aluminum alloy.



(1)40-frame (2)35-frame

Figure 4：5400 Pa Solidworks analysis

At the same time, the mechanical load stress analysis of photovoltaic modules was carried out in the tiled installation mode, and it was concluded that the maximum stress point of the module was located in an elliptical orbit around the module during the mechanical load of 5400Pa, as shown in Fig. 6.As can be seen from the figure, the faster the color changes, the greater the deformation of the component and the greater the stress.. The green area has a large trend of color change, this part is the location where photovoltaic modules are subjected to the greatest stress.On the contrary, the blue and red parts in the figure are the positions where the relative stress of the photovoltaic modules is low.

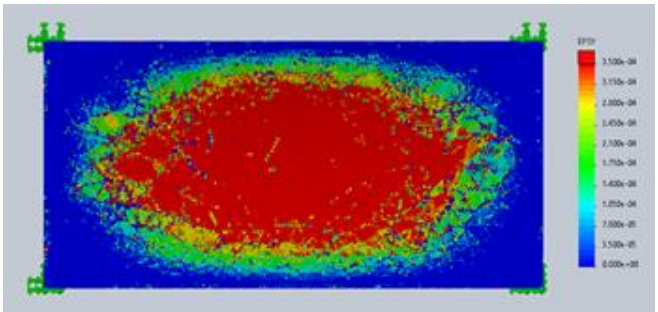


Figure 5. 5400Pa contour map

3.2. Mechanical load test

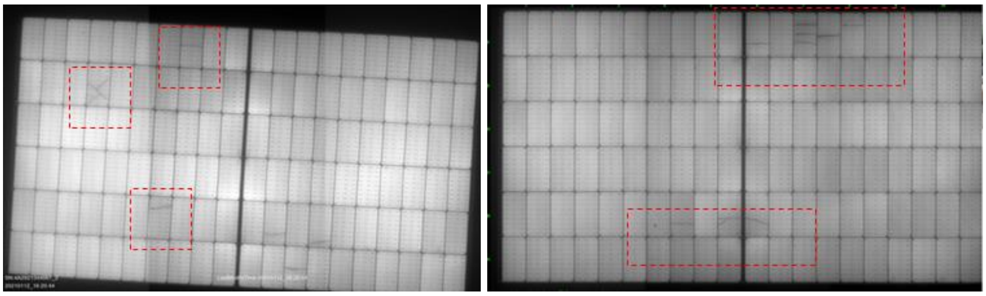
3.2.1 Mechanical load test at inclined Angle

Table 2 shows the output power of PV modules in test 1 and test 2 before and after the mechanical load test in the inclined Angle mode. It can be seen from the table that there are differences in the output power attenuation of aluminum alloy frames with different cross-section structures. The attenuation rate of 35-frame is slightly better than that of 40-frame.

Table 2 mechanical load experiment at inclined Angle

Items		Pmax	Isc	Voc	Ipmax	Vpmax	Rate
Test1	Before	372.77	11.24	41.15	10.79	34.56	-0.69%
	After	370.20	11.17	41.14	10.77	34.39	
Test2	Before	372.93	11.25	41.12	10.75	34.68	-0.74%
	After	370.17	11.17	41.08	10.66	34.74	

Fig. 7 shows the EL test image after the mechanical load test of Test 1 and Test 2. It can be seen that in the EL image after the mechanical load of 35-frame, the number of micro-crack is 6, and the micro-crack rate is 5%, without causing the phenomenon of blackening and failure of the cell. In the EL picture after the mechanical load of 40-frame, the number of micro-crack is 7, and the micro-crack rate is 5.8%. Again, there is no fragment and failure of the cell.



(1) 35-frame EL (2) 40-frame EL

Figure 6: EL image of tilted component after mechanical loading

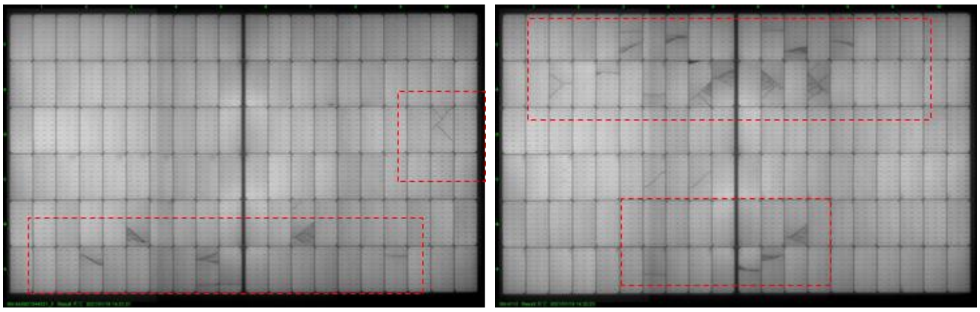
3.2.2 Mechanical load test at tiling machinery

In the tiled mode of Test 3 and Test 4, the output power of photovoltaic modules before and after the mechanical load test is shown in Table 3. It can be seen from the table that there are differences in the attenuation of frame output power of different cross-section structures. The absolute value of attenuation rate of 40-frame is 0.56% higher than that of 35-frame.

Comparing the EL images of two groups of experiment after mechanical loads, it was found that after mechanical loads, there were 8 EL micro-crack in the 35-frame PV modules, and the crack rate was 6.7%. 4 EL micro-crack were reticular cracks, but no fragment and failure of the cells were caused. After the mechanical load of 40-frame, there were 18 EL micro-crack, with a crack rate of 15%, which 7 were reticular cracks, and a small part of the cells had fragment and failure, as shown in Fig. 8.

Table 3 mechanical load experiment at tiling machinery

Items		Pmax	Isc	Voc	Ipmax	Vpmax	Rate
Test3	Before	366.96	11.09	41.22	10.56	34.75	-0.93%
	After	363.53	11.02	41.14	10.55	34.46	
Test4	Before	367.01	11.06	41.11	10.57	34.73	-1.49%
	After	361.56	11.00	40.89	10.55	34.28	



(1)35-frame EL (2)40-frame EL

Figure 7 : EL image of tiled mode after mechanical loading

Comparing the output power and EL images of the photovoltaic modules with different sections of aluminum frames in different installation modes, it is can be seen that the effect of 35-frame aluminum alloy under mechanical load is better than 40-frame aluminum alloy. At the same time, it can be seen that the crack location tested by EL is consistent with the stress concentration point simulated by SolidWorks software in 3.1.

3.3. Contrastive analysis of different section structures

Table 4. shows the bending deformation of aluminum frames with different sections under mechanical load in the tiling mode. It can be found from the measured data that the bending

deformation of 35-frame at 5400Pa is 8cm from the bottom bearing platform, and that of 40-frame at 5400Pa is 6cm from the bottom bearing platform. Under the condition of no external force, the distance between the two panels of photovoltaic modules and the bottom bearing platform is 2cm.So the actual deformation of 35-frame is 6cm, and the actual deformation of 40-frame is 4cm.It can be seen that the degree of 40-frame deformation is less than that of 35-frame.So the mechanical strength of 40-frame is better than that of 35-frame.This is also consistent with the results of the SolidWorks software simulation of the form variable in 3.1.

Table 4 Bending deformation under mechanical loads of different sections

Item	Frame	Platform	Zenith	Deformation
Test3	35-Frame	2 cm	8 cm	6 cm
Test4	40-Frame	2 cm	6 cm	4 cm

4. Conclusion

This paper studies the protective effect of aluminum frames with different sections on photovoltaic modules, and tests the output performance and EL image of photovoltaic modules under tile and inclined Angle installation modes by means of mechanical load experiment. Through testing and SolidWorks software simulation, it can be seen that:1). The output electrical performance of photovoltaic modules with large aluminum frame deformation is better than that of photovoltaic modules with small deformation. It can be seen that the output electrical performance of photovoltaic modules is not completely positively correlated with the mechanical load shape variable of photovoltaic modules.2) When photovoltaic modules are subjected to external forces, the larger the deformation of local area of photovoltaic modules is, the greater the stress will be, and the more serious the damage of photovoltaic modules will be..

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References

[1] Goswami D Y . Advances in Solar Energy: Volume 17: An Annual Review of Research and Development in Renewable Energy Technologies[M]. 2015.
[2] Pimentel D . Renewable and Solar Energy Technologies: Energy and Environmental Issues[J]. Springer Netherlands, 2008.
[3] Lupu A G , Dumencu A , Atanasiu M V , et al. SWOT analysis of the renewable energy sources in Romania - case study: solar energy[J]. Iop Conference, 2016, 147(1):012138.
[4] Curran L , Lv P , Spigarelli F . More heat than light? Renewable energy policy and EU-China solar energy relations[J]. International journal of ambient energy, 2017, 38(5-8):471-480.
[5] Hoeft D . Solar module assembly mounted on flat roof, comprises frame of triangular cross section supporting sloping solar panels and sheet metal covering[J]. WO, 2007.
[6] Wei W H , Zhu Y N , Xue T M , et al. Optimization of the Frame and Performance Analysis of Solar Modules Based on Ansys Workbench and Solidworks[J]. Key Engineering Materials, 2016, 693:169-173.
[7] Ehbing H , Schauseil F , Hoffmann A , et al. Photovoltaic solar module having a polyurethane frame[J]. US, 2013.
[8] Kajari-Schr?Der S , Kunze I , Eitner U , et al. Spatial and orientational distribution of cracks in crystalline photovoltaic modules generated by mechanical load tests[J]. Fuel & Energy Abstracts, 2011, 95(11):3054-3059.

[9] Park J , Noh E S , Yoon J K , et al. Study on High Transparent PV Backsheet for Bifacial Solar Module[J]. Transactions of the Korean Institute of Electrical Engineers, 2019, 68(2):370-375.
[10] Lan W L , Chu K H , Hsu C C . Transparency and water-resistance enhancement of AR coating for the cover glass in the solar cell module[C]// 2014 53rd Annual Conference of the Society of Instrument and Control Engineers of Japan (SICE). IEEE, 2014.

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